Reflective pondering is associated with executive control for emotional information

Reflective pondering is associated with executive control for emotional information: An adolescent prospective study

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1. Introduction

Rumination has been identified as a key vulnerability in the development of depression. Rumination, which consists of persistent focusing of attention on depressive affect and its consequences, exacerbates depression and negative thinking while also impairing problem solving (Nolen-Hoeksema 1991). There is a wealth of research linking rumination to the development, severity and maintenance of depression both cross-sectionally (Kuyken, Watkins, Holden, & Cook, 2006; McMurrich & Johnson, 2008) and longitudinally (Nolen-Hoeksema & Morrow, 1991; Schwartz & Koenig, 1996; Verstraeten, Vasey, Raes & Bijtterbeir, 2010), in both child (Abela, Brozina, & Haigh, 2002; Abela & Hankin, 2011; Abela, Vanderbilt, & Rochon, 2004; Broderick & Korteland, 2004; Kuyken et al., 2006) and adult populations (Nolen-Hoeksema, 2000; Smith & Alloy, 2009). Depression is one of the most common and incapacitating mental health disorders and, despite a wealth of research investigating the disorder, it is characterised by high prevalence and relapse rates (Ayuso-Mateos et al., 1999). Preventing or delaying depression onset can alter the developmental path and debilitating suffering across adulthood (Andrews, Szabo & Burns, 2002). In addition, first onset typically occurs during adolescence and 20-50% of adolescents report significant depressive symptoms (Kessler, Avenevoli, & Merikangas, 2001). There has been a shift within the literature to better understand the factors associated with vulnerability to depressive symptomatology during adolescence.

One such line of research is the investigation of the links between rumination and impaired executive control. Impairments in executive control, generally regarded as synonymous with the term cognitive control, have been identified as a key vulnerability factor for the development and maintenance of depression (Castaneda, Tuulio-Henriksson, Marttunen, Suvisaari, & Lönnqvist, 2008; Joormann & D'Avanzato, 2010; Mathews & McLeod, 2005) and further linked to the tendency to ruminate in adult populations

(Altamirano, Miyake, & Whitmer, 2010; Davis & Nolen-Hoeksema, 2000; Koster, De Lissnyder, Derakhshan, & De Raedt, 2011; Whitmer & Banich, 2007). Difficulties in executive control have also been reported in those who are currently depressed (De Lissnyder, Koster, Everaert, Schacht, Van den Abeele, & De Raedt, 2012), highlighting the co-occurring relationship between executive control and depression. A specific definition of executive control continues to be specifically 'elusive to define' (Epsy & Bull, 2005). However, it is largely accepted in the literature, and by the authors, that executive control is a broad term that refers to a group of cognitive processes which are responsible for the flexible coordination and control of executive functions and processes towards a specific goal (Roberts, 1998; Shah & Miyake, 1999; Williams et al., 2007). Developments in the field have suggested that there are three main separable, but related executive functions; inhibition, updating working memory and switching (Miyake et al., 2000). There is a continuing effort to clarify the nature, components and definition of executive/cognitive control/functions (for an overview of the literature, and developmental progression see Diamond, 2013). While there is debate in the literature, there is general agreement that executive/cognitive control refers to the control of cognitions accountable for the planning, initiation and monitoring of complex goal directed behaviour, particularly when distracting information is present (Dalgleish et al., 2007). These abilities allow individuals to respond flexibly and to adjust emotional responses and behaviour to changing situations (Joormann & D'Avanzato, 2010).

While research investigating the relationship between cognitive abilities, particularly executive control and rumination, is progressing within the adult literature, studies examining this relationship in adolescence are limited. From a developmental perspective, it is particularly important to investigate the relationship between executive control and rumination specifically within adolescence as this developmental period is characterised by rises in rumination (Hyde, Mezulis & Abramson, 2008) and depressive symptoms (Mezulis,

Funasaki, Charbonneau, & Hyde, 2010) which can become habitual. This can place adolescents at heighted risk of depression (Mezulis, Priess & Hyde, 2010). Research has continually suggested that adolescence is a heightened risk period for the development of psychopathology, especially depressive and anxiety symptoms (McLaughlin & Nolen–Hoeksema, 2011; Twenge & Nolen–Hoeksema, 2002). Moreover, adolescence marks a period of ongoing development and maturation of the prefrontal cortex associated with cognitive abilities (Paus, 2005) and the relationship between rumination and executive control may be influential in enhancing the understanding of this development. Importantly, executive control is a key cognitive skill which supports goal directed behaviour and is linked to educational achievement in children and adolescents (St. Clair-Thompson & Gathercole, 2006). Conversely, impairment in executive control processing can reduce the ability to inhibit negative information and respond flexibly, resulting in reduced problem solving and reduced capability to change behaviour (Henry & Bettany, 2010). A greater understanding of rumination and its relationship with executive control, particularly in children and young people, could also enhance our knowledge of cognitive vulnerability to depression and may allow for targeted interventions to prevent the development of vulnerability factors. For example, it has been argued that it may be unrealistic to assume that interventions to reduce depression would be successful if the underlying vulnerability is not addressed first (Koster et al., 2011).

Connolly et al. (2014) investigated the relationship between executive control and rumination in adolescence, employed an array of neutrally valenced cognitive tasks to prospectively examine selective attention, sustained attention, attentional switching, divided attention and working memory, as well as rumination and self-reported depressive symptoms in a large community sample of adolescents. Heightened baseline rumination scores predicted deficits in attentional switching (also known as switching; set-shifting; cognitive flexibility)

at follow up 15 months later. However, research has not yet tested whether specific subtypes of rumination such as brooding or reflective pondering impact executive control differently or whether this this effect would still be found when emotional measures are employed.

Rumination involves a passive focus on negative emotions, so a relationship between rumination and executive control may be more prominent on tasks which use emotional stimuli. A growing body of research supports the link between rumination and processing emotional information. For example, when emotional tasks have been employed within the adult literature, findings highlight a relationship between rumination and executive control impairments (De Lissnyder, Koster, Derakshan, & De Raedt, 2010; De Lissnyder, Koster, & De Raedt, 2012; Demeyer, De Lissnyder, Koster, & De Readt, 2012). In adolescence, Hilt, Leitzke and Pollak (2014) reported a cross-sectional positive association between rumination and reduced executive control (particularly when inhibiting emotional information), although Wilkinson and Goodyer (2006) reported no such association. The disparity in the findings could be due to the valence of tasks as Hilt et al. (2014) employed emotional and non-emotional tasks of executive control whereas Wilkinson and Goodyer (2006) employed only neutral tasks. However, Connolly et al. (2014) found a positive relationship between rumination and reduced executive control ability when employing neutral tasks. It is evident that further research is warranted, particularly with adolescent populations, at a time when rumination and cognitive functions are rapidly developing.

With respect to rumination, Treynor, Gonzalez and Nolen-Hoeksema (2003) reported a two factor model with 'reflective pondering' and 'brooding rumination' as two ruminative subtypes. Brooding rumination is a maladaptive form of rumination and has been defined as focusing attention on the meaning of negative, judgemental and self-blaming thoughts (Cox, Funasaki, Smith, & Mezulis, 2011; Treynor et al., 2003). It is implicated in the onset and severity of depression in adolescence (Burwell & Shirk, 2007; Gibb, Grassia, Stone, Uhrlass,

& McGreary, 2012) as well as preliminary research with adults proposing a positive link between brooding rumination and impairment in executive control (De Lissnyder et al., 2012; Whitmer & Banich, 2007), although some have reported no association between brooding rumination and executive control (Vanderhasself, Koster, Goubert and Raedt, 2012).

In contrast, reflective pondering is an adaptive form of rumination and is defined as focusing attention on neutral or positive content, non-judgmentally, with a focus on problem solving (Treynor et al., 2003; Whitmer & Gotlib, 2011). The literature on reflective pondering is mixed. For example, research suggests that reflective pondering is a protective factor against symptoms of depression (Treynor et al., 2003), predictive of later recovery from depression (Arditte and Joormann, 2011), and has been associated with lower levels of depression in children over 11 years old (Verstraeten et al., 2010) although such findings are not always found (Cox et al., 2012; Paredes & Zumalde,. 2015). Reflective pondering has also been associated with less grief and depressive symptoms following bereavement (Eisma et al., 2015) as well as greater coping in adolescent girls (Burwell & Shrik, 2007), proposing that reflective pondering may an adaptive form of rumination. It should be noted however that some research has suggested a positive link between reflective pondering and psychopathology (Joormann et al., 2006) as well as suicidal ideation (Miranda & Nolen-Hoeksema, 2007), although with stronger effects to brooding rumination than reflective pondering.

Despite differences between the subtypes of rumination, most adolescent studies of rumination and executive control examine rumination as a single construct rather than as multidimensional (e.g. Connolly et al., 2014). In the adult literature, brooding rumination has been positively associated with executive control impairments (De Lissnyder et al., 2012), yet the relationship between reflective pondering and executive control is less clear. For example, while Vanderhasself, Koster, Goubert and Raedt (2012) found a relationship between

reflective pondering and executive control, in which participants with lower impairment in executive control, in comparison to those with greater impairment, were able to activate reflective pondering in times of stress, other research has reported no such relationship between reflective pondering and executive control (De Lissnyder et al., 2012). Given the differential associations that each form of rumination has, both within the executive control and wider psychopathology literature, it is important to consider both forms of rumination when seeking to better understand links with executive control. This can enhance our understanding of cognitive vulnerability to psychopathology during adolescence.

To the best of our knowledge, this is the first study to investigate the prospective relationship of rumination on executive control by employing emotional and non-emotional measures of executive control for internally represented information as well as investigating rumination by its subcomponents, brooding and reflective pondering within adolescent development. Based on existing evidence in the literature, we predict that:

1. Reflective pondering at baseline will predict greater levels of executive control when processing emotional and non-emotional information at follow-up;
2. Brooding rumination at baseline will predict lower levels of executive control when processing emotional and non-emotional information at follow-up.

2. Method

2.1 Participants

A community sample of adolescents was recruited from three secondary schools across Scotland, UK. Information packs were sent home with all children between the ages of 13 to 16 years in participating schools. Consent was sought from each parent or guardian and written assent was required at both waves of the study from each adolescent. Following Gathercole, Pickering, Ambridge and Wearing (2004), no exclusion criteria were applied at

recruitment. All adolescents available on the days of testing, with appropriate parental consent and written assent, participated in the study. The sample consisted of 149 adolescents (36% male) tested at wave 1 (W1; mean age = 13.85, SD = 0.78) and 136 adolescents (37% male) and subsequently retested approximately six months later at wave 2 (W2; mean age = 14.28, SD = 0.88). The number of children within a school who were eligible for free school meals (FSM) was used as a proxy for schools' socio-economic disadvantage and deprivation (Hobbs & Vignoles, 2010) between participating and non-participating schools. The schools in the current study had a 16% eligibility of FSM (10% typical mean in Scotland), which suggests that participating schools were of low/moderate socio-economic disadvantage and with no difference in socio-economic status between participating and non-participating schools (p = .12). Thirteen participants (5 males and 8 females; 8.8% total) from W1 did not complete the study at W2. This was due to scheduling difficulties, participants graduating from school and a family bereavement resulting in the withdrawal of one participant.

2.2 Procedure

All tasks were conducted in schools. At W1, children were individually administered a battery of assessments, including a computerised emotionally-valenced executive control task, a measure of rumination, and self-report questionnaires of depressive and anxiety symptoms. At both time points, assessments of rumination, depressive and anxiety symptoms were randomised to control for order effects and were completed at the end of the session to avoid mood priming effects.

2.3 Measures

2.3.1 Depression: The Beck Depression Inventory-II (BDI; Beck, Steer, Ball & Ranieri, 1996) was used. The BDI-II is a 21-item self-report questionnaire measure of depression symptoms developed to measure symptoms of depression in adolescent and adult

samples. Each item contains four statements reflecting varying degrees of severity. Participants are instructed to circle the number (ranging from zero to three, demonstrating increasing severity) that corresponds with the statement that best describes how they are feeling. Scores are summed to calculate a total BDI–II score, which can range from 0 to 63. The BDI-II has shown good internal consistency (α = .91; Osman, Barrios, Gutierrez. Williams & Bailey, 2008) when applied to non-clinical adolescent samples. The 'suicidal ideation' and 'sex' questions were removed from the scale as these were deemed inappropriate for the age of the sample and the prospective design of the study (i.e. lacking in anonymity). Previous research has omitted these items for similar reasons (Balazs et al., 2013; Basner et al., 2014; Osman, Kooper, Guttierez, Barrios & Bagge, 2004; Wisco & Nolen-Hoeksema, 2010). The BDI-II scores within the current study showed excellent internal consistency at (α = .94).

2.3.2 Anxiety: The Multidimensional Anxiety Scale for Children 2nd Edition (MASC-II; March, Parker, Sullivan, Stallings, & Conners, 1997) was used. The MASC-II is a 50-item self-report measure developed to assess a wide range of anxiety symptoms in children and adolescents. Each item is rated on a 4-point Likert-type scale with higher scores indicative of greater anxiety. The MASC has demonstrated good internal consistency (March et al., 1997), particularly in non-clinical adolescent samples (Muris, Merkelbach, Ollendick, King, & Bogie, 2002) and good test-retest reliability (r = .87; March et al., 1997). The MASC displays significant correlations (r = .63) with other anxiety measures, but non-significant correlations (r = .19) with measures of depression (March et al., 1997). The MASC-II scores for the current data showed excellent internal consistency at (α = .94).

2.3.3 Rumination: The Ruminative Response Scale of the Response Style Questionnaire Rumination (RRS; Nolen-Hoeksema, 1991) was used. The RRS is a 21-item

response scale which describes ruminative responses. Each item is on a 4-point Likert-type scale (1= never to 4 = always) with higher scores indicative of great ruminative styles. Following the work of Treynor et al. (2003) the 5-item reflective pondering and the 5-item brooding rumination subscales were extracted from the RRS. Treynor et al. (2003) reported a coefficient alpha of .72 and .77 for the reflection and brooding subscale respectively. The current data showed adequate internal consistency for reflection (α = .77) and brooding (α = .79). Good test–retest reliability was also found for both the brooding sub-scale ($r = .68$, $p < .001$) and the reflective pondering sub-scale ($r = .66$, $p < .001$).

3.3.4 Executive control: Internal Switch Task (IST; De Lissnyder et al., 2012) was used. The IST is a valenced, computerised measure of internal executive control. Chun, Golomb, and Turk-Browne, (2011) have suggested that there are two ways of processing information, internal processing which is the processing of internally generated information, and external processing which is the processing of information from the external world. Building on previous task designs (Chambers, Lo, & Allen, 2008; Garavan, 1998; Gehring, Bryck, Joindes, Albin, & Badre, 2002). The IST is a measure of internal executive control as it measures switching ability between internally generated information held in working memory. Whilst the IST is primarily a measure of switching ability, it also involves the ability to inhibit and over-ride previous previously relevant information and update working memory. Although executive functions have been shown to be separable (Miyake et al., 2000), research suggest that different functions, particularly switching, relies and builds on other executive functions such as working memory and inhibition (Diamond, 2013). In support of this, Koch, Gade, Schuch, and Philipp (2010) reviewed the literature and found switching and inhibition to be highly interrelated. As such, the IST was framed in terms of task demands, providing a measure of top-down executive control.

In the IST, faces were presented one at a time on the centre of a computer screen. The faces were taken from the Karolinska Directed Emotional Faces (KDEF) (Lundqvist, Flykt, & Öhman, 1998) and 24 angry and 24 neutral faces, either male or female were selected based on a validation study of the KDEF faces (Goeleven, De Raedt, Leyman, & Verschuere, 2008). There were two conditions; a non-emotional task condition and an emotional task condition. There were 12 blocks of trials within each condition and each trial presented 10-14 randomised faces. The participants task was to keep a mental count of the number of faces which appeared on the screen. As such, participants switched between internally generated information (i.e. mental count of the number of male vs female, or angry vs neutral faces). Participants were given a practice phase before the start of each condition, this consisted of three practice trials relevant to the subsequent condition.

In the non-emotion condition, faces appeared on the screen one at a time and the participants task was to focus on the non-emotional features of the face (i.e. categorised as male vs. female) and keep a mental count of the number of male and the number of female faces that appear on screen in each trial. After each face appeared on the screen, participants were asked to press the spacebar as fast as possible (reaction time measure) once they had updated their mental count. At the end of each trial, participants indicated using the number path on the keyboard, how many faces they had counted in each trial. This condition measured the time taken to switch between their mental counts (i.e the internally generated information of the number of male and female faces). In the emotion condition, faces also appeared on the screen one at a time and the participants task was to focus on the emotional features of the face (i.e. categorised as angry vs. neutral) and keep a mental count of the number of angry and the number of neural faces that appear on screen in each trial. After each face appeared on the screen, participants were asked to press the spacebar as fast as possible (reaction time measure) once they had updated their mental count. At the end of each

trial, participants indicated using the number path on the keyboard, how many faces they had counted in each trial. This condition measured the time taken to switch between their mental counts (i.e. the internally generated information of the number of angry and neutral faces). The conditions were counterbalanced between participants to control for within task order effects.

Faces had an inter-trial interval of 200ms between the presentation of each face. An example of a block of trials in each condition is shown in Figure 1. To avoid the possibility of any trials becoming sequenced and predictable to the participants, the order of the trials and presented faces were randomly determined with a replacement procedure. As each face was randomly presented it created a measure of switch costs (male - female; female - male; angry - neutral; neutral – angry) and no-switch costs (male – male; female – female; angry – angry; neutral – neutral) within each trial. The difference in reaction time between switch and no-switch costs were calculated and used for analysis. Switch costs reflect internal control processes that are engaged when participants switch between operations or mental sets. Median scores were used to reduce the influence of outliers on the data (De lissnyder et al., 2012). Correct and incorrect trials were included in the analysis. The IST has been shown to have good internal consistency as well as good re-test reliability when all trials are included (Koster, De Lissnyder, & De Raedt, 2013). The current data showed good internal consistency for both the emotion condition (α_{W1} = .80; α_{W2} = .80) and the non-emotion condition (α_{W1} = .81; α_{W2} = .77) as well as modest test-retest reliability in the emotion condition (r = .48, p < .001) and non-emotion condition (r = .38, p < .01).

[Insert Figure 1 here]

2.4 Analytic Strategy:

Data analysis proceeded in two stages. First, our data management procedures were as follows: data were screened for skew and missing data. Skewness and kurtosis values were between -1.0 and +1.0, and therefore no data transformation was required. Data from two participants had a significant Mahalanobis D^2 value (p <.001) and were considered multivariate outliers and were excluded from subsequent analyses. These were excluded to meet the assumptions of the subsequent analyses (Field, 2013). This reduced the sample size to 147. Sample size was determined using Tabachnick and Fidel's (2007) formula (104 + number of predictors) based on detecting a medium effect size, with a power of .80. The significance level was set at α <.05. Based on this formula, a minimum sample size of 112 was required.

Examination of the data revealed that 82.99% of participants (N = 122) had a complete data set across all the measures at W1 and 74.15% at W2 (N = 109). Data for W2 attrition (i.e.13 participants) was coded as W1 data. Missing item data was only found within the depression and anxiety measures, and no single item in the data set had more than 2% of missing data (range from 0.7% - 2%). Little's MCAR test was conducted: χ^2 = 3,584.44 (df = 3553; p = .35), noting that missing data was missing completely at random and no pattern exists within the data set. Missing item data was imputed using Multiple Imputation (MI) in SPSS. MI was used as it provides unbiased estimates when the data is missing completely at random or missing at random and therefore produces more accurate parameter estimates than traditional methods (Baraldi & Enders, 2010). In addition, as no single item in the present data set had more than 2% of data missing, the MI method can be effective when up to 80% of data are missing (Lee & Huber, 2011). Imputed values were within the same range as the original data (i.e. BDI-II had a score of 0, 1, 2 or 3) and five data sets were imputed. Imputed data created a data set which allowed analysis on 100% of the final participant sample (N = 147).

Next, multiple linear regression analyses were used to evaluate the prospective relationships of both brooding rumination and reflective pondering on executive control. In all analyses, age, sex, baseline covariates and depressive and anxiety scores were added at step 1 to control for their effects. Previous research has indicated that current depressive and anxiety symptoms can impact task performance on a range of cognitive tasks in a way that conceals the unique relationship between rumination and executive function (Altamirano et al. 2010; Cisler & Koster, 2010). Similarly, given the shared variance of brooding rumination and reflective pondering, these were covaried respectively. At step 2, predictor variables were added to investigate the unique additional contribution to the outcome variables after controlling for step 1 variables. Pooled estimates for the unstandardised coefficients (with standard errors) and for significance testing of these were created through SPSS. Where pooled estimates were not available, estimates were averaged across all 5 imputed data sets (Jones, Heim, Hunter, & Ellaway, 2014).

3. Results

Means and standard deviations for the main study variables and paired-samples *t*-test analyses to examine time point differences are presented in Table 1. Bivariate correlations for within and across time points are displayed in Table 2. As expected, the bivariate correlations at W1 and at W2 indicate that executive control for emotional information and non-emotional information and both forms of rumination, all significantly correlated. In terms of bivariate correlations between W1 and W2 variables, W1 reflective pondering was significantly negatively correlated with W2 executive control for emotional information but not with W2 executive control for non-emotional information. W1 brooding rumination was not correlated with W2 executive control for emotional or non-emotional information. W1 executive control for emotional information was more strongly correlated with W2 non-emotional task than the

W1 non-emotional task. We are unclear as to the basis of this finding, but as the two tasks are related and only differ in processing different features of the stimuli, we would expect these tasks to correlate. There were no problems with multi-collinearity (all VIF <3) in the regression models and specific to our models, Durbin-Watson tests for both steps in both models supported the conclusion that autocorrelation was not a significant problem. We found no evidence against this assumption.

[Insert Table 1 here]

[Insert Table 2 here]

Multiple regression analysis was conducted to predict W2 executive control (measured by larger switch costs) when processing emotional and non-emotional information, respectively.

In the emotion condition (see Table 3), the first step of the regression accounted for a significant portion of variance in switch costs.. Almost one third (31%) of the variation in switch costs when processing emotional information can be accounted for by the variables entered at the first step in the regression (Step 1: F (7, 139) = 8.83, p <.001. R^2 = .31). Significant individual predictors of W2 switch costs when processing emotional information were sex and W1 switch costs for both emotional and non-emotional information processing. W1 brooding rumination was not a significant predictor of W2 switch costs when processing emotional information. At step 2, switch costs in the emotion condition were regressed on W1 reflective pondering to examine the unique contribution on switch costs when processing emotional information (Step 2: F (1, 138) = 4.76, p = .03. R^2 = .03). W1 reflective pondering was a significant predictor of W2 switch costs when processing emotional information. The model accounted for a significant additional portion of variance, on average 3% across the

five imputed data sets[1]. Across the five imputed data sets, all betas were almost identical (difference in βs = .01)[2]. Sex and W1 switch costs in the emotion and non-emotion conditions were significant predictors of W2 switch costs when processing emotional information in both steps of the model.

In the non-emotion condition (see Table 4), the first step of the regression accounted for a significant portion of variance in switch costs. Over one quarter (26%) of the variation in switch costs when processing non-emotional information can be accounted for by the variables entered at the first step in the regression (Step 1: F (7, 139) = 6.89, p <.001. R^2 = .26). Significant individual predictors of W2 switch costs when processing non-emotional information were W1 switch costs for both emotional and non-emotional information. W1 brooding rumination was not a significant predictor of W2 switch costs when processing non-emotional information. At step 2, switch costs in the non-emotion condition were regressed on W1 reflective pondering to examine its unique contribution to switch costs when processing non-emotional information (Step 2: F (1, 138) = 3.25, p = .08. ΔR^2 = .02.). W1 reflective pondering was not a significant predictor of W2 switch costs when processing non-emotional information (p = 0.08). W1 switch costs in the emotion and non-emotion conditions were significant predictors of W2 switch costs when processing non-emotional information in all steps of the model.

[Insert Table 4 here]

[1] Separate analyses was conducted on the original data without the use of multiple imputation by removing participants with missing data (N = 25). Reflective pondering was still a significant, negative predictor of executive control impairment at follow up (β = -.28, p = .01).

[2]Additional analyses were run to evaluate the prospective relationship of executive control on rumination, both brooding and reflection given the significant correlation between W1 switch cost emotion condition and reflective pondering at W2. As in the original analysis above, age and sex, baseline covariates and depressive and anxiety scores were added at step 1 to control for their effects. W1 switch costs when processing emotional information did not significantly predict W2 brooding rumination (p = .64) or W2 reflective pondering (p = .64). Similarly, W1 switch costs when processing non-emotional information did not significantly predict W2 brooding rumination (p = .25) or W2 reflective pondering (p = .37).

4. Discussion

The primary aim of this research was to examine the subcomponents of rumination on executive control over time in adolescence. The study included a focus on the processing of both emotional and non-emotional information and on both subtypes of rumination (brooding rumination and reflective pondering). Findings revealed that higher levels of reflective pondering at W1 were predictive of decreased switch costs (greater executive control) when processing emotional information at W2. Moreover, this relationship was present after accounting for age, sex, baseline scores, and symptoms of both depression and anxiety. This suggests that reflective pondering may be adaptive for adolescents in allowing for greater executive control abilities when processing and switching between emotional information, although further research is warranted to confirm findings Interestingly, brooding rumination did not predict executive control in either the emotion or non-emotion condition. Taken together, the results of the current study highlight the unique predictive contribution of reflective pondering on executive control, specifically for emotional information.

Although no research has directly reported the effects of reflective pondering on executive control for internally represented emotional information within adolescents, other research has highlighted reflective pondering as a positive construct. Indeed, reflective pondering has been associated with recovery from depression (Arditte & Joormann, 2011; Verstraeten et al., 2010), reduced grief in bereavement (Eisma et al., 2015) and coping in adolescent girls (Burwell & Shrik, 2007). Our unique strategy of separating out reflective pondering and brooding rumination, as well as investigating executive control for emotional and non-emotional information added nuance to Connolly's (2014) findings who found rumination as a whole construct was predictive of later deficits in executive control. While brooding rumination, the maladaptive form, did not lead to lower levels of executive control

in our study, reflective pondering was associated with greater executive control over emotional information at follow up. The current findings also support recent research with adult populations who found an association between reflective pondering and executive control (Vanderhasself et al., 2012). These findings, with our own, highlight the adaptive relationship between reflective pondering and executive control.

Contrary to previous research in adult samples (De Lissnyder et al., 2012; Koster et al., 2011) brooding rumination was not associated with executive control impairment in our sample. The adult, as well as child and adolescent literature, does tend to support the theory that rumination as a whole construct is associated with executive control deficits (Connolly et al., 2014; De Lissnyder et al., 2010; De Lissnyder et al., 2011; Whitmer & Banich, 2007), and in particular brooding rumination (De Lissnyder et al., 2012), even when depressive symptoms are controlled for (Joormann, Drake & Gotlib, 2006). The conflicting findings may arise from variation in follow up times in multi-wave, prospective studies as these differ greatly across studies. Vanderhasself et al. (2012) utilised a 6 week time frame, testing young adult participants weekly within this time. The authors did not find a relationship between brooding rumination and executive control in their sample. Connolly et al. (2014) employed a 15 month follow up, with two testing sessions and an adolescent sample and reported a relationship between rumination (as a whole construct) and a measure of executive control. The current study which had two testing sessions approximately six months apart did not find an association between brooding rumination and executive control. It could therefore be argued that a follow-up period for examining the relationship between brooding rumination and executive control should be no less than 6 months to allow for brooding rumination to exert its effect to a degree that would be reflected in higher levels of executive control.

The current study produced further findings of interest. Depressive symptoms at W1 were correlated with reflective pondering at W1. One possible explanation for this finding is

that those individuals experiencing depressive symptoms were trying to overcome their depressive symptoms by engaging in reflective pondering. Joormann et al. (2006) noted that individuals with elevated levels of depressive symptoms or a diagnosis of depressive disorder were more likely to engage in reflective pondering as well as brooding rumination in comparison to non-depressed individuals. However, given the cross-sectional nature of these W1 findings (i.e. correlation between W1 depression and W1 reflective pondering) it is not possible to infer causality, but it does stress the importance of controlling for symptoms of depression when investigating rumination. The finding that females are more likely to experience lower executive control than males could reflect sex differences in found in depression. For example, research findings suggest that females are more at risk of developing depressive disorders that begin in adolescence and persist throughout adulthood than males (Piccinelli & Wilkinson, 2000) and it may be that these sex differences are present in vulnerability factors, such as executive control.

A strength of the current study is its use of a prospective design and thus sensitivity to changes over time within an adolescent population. In addition, it considered valence-specific changes in executive control by utilising a measure that included emotional and non-emotional aspects as well as employing a measure of rumination which permitted specific analysis of adaptive and maladaptive forms of rumination and their relationship with executive control. Finally, effects of depressive symptoms and comorbid anxiety symptoms on outcomes were controlled for as research has shown even subclinical anxiety and depression levels can adversely affect executive control (Ansari & Derakshan, 2010; 2011; Holmes & Pizzagalli, 2007).

In addition to these strengths, a number of limitations and future recommendations are noted. Like previous research in this area (Connolly et al., 2014) we had one follow up session, after the initial baseline assessment. The use of multiple time points in the design,

along with a longer follow up, could have permitted a more advanced evaluation of the relationship between executive control and rumination in adolescence. For example, Davidson and colleagues investigated age related differences in the development of executive function and control processing from 4 to 26 years old (see Davidson, Amso, Anderson, & Diamond, 2006). They noted that executive function and control processes, specifically switching ability, differed across age and was progressive past the age of 13 years. Future research is warranted that systematically examines executive control and rumination across varying time points to clarify more specifically how and when these factors begin to relate to one another and subsequently to depressive symptoms across the adolescent period. Despite good internal consistency, the executive control task had low/moderate test-retest reliability in our sample. As noted by many researchers in this area, tests of executive function and executive control are limited by their test-retest reliabilities (Burgess, 1997; Miyake et al., 2000). A recent review highlighted test-retest reliabilities as low as .20 for some cognitive tasks (Henry & Bettenay, 2010). Although not very well understood in the literature, Rabbitt (1997) argues that the ability to exert executive control is strongest when a task is novel and as a task can only be novel once this is likely to explain the low test-retest reliabilities in this area. It is also possible that the low test-retest reliabilities in executive control reflect the ongoing changes in executive control (Rutter & Rutter, 1993) that occur though the adolescent transition.

Notwithstanding these limitations, the current findings demonstrated that reflective pondering was predictive of greater executive control when processing emotional information. To the authors' knowledge, the current study is the first to examine the subcomponents of rumination on executive control for internally represented emotional and non-emotional information processing prospectively with an adolescent sample, while controlling for the possible effects of anxiety and depressive symptoms. The findings have a

number of theoretical and clinical considerations. Our findings support theory in which reflective pondering is an adaptive factor (Treynor et al., 2003), and add to this by demonstrating its adaptive properties specifically on executive control when processing emotional information. The adaptive nature of reflective pondering could have important clinical implications. For example, preventative interventions to increase reflective pondering could increase executive control abilities and subsequently lead to reduced symptoms of depression given that impairments in executive control are a known vulnerability to depression. It is important to note, Joormann et al. (2006) have suggested that while brooding rumination and reflective pondering were separate constructs in non-clinical groups, in clinical samples reflection and brooding perpetuate each other, concealing the distinction between them. Thus, it is possible that reflective pondering may be adaptive in non-clinical populations, however in clinical populations the adaptive qualities of reflective pondering could become blurred with the maladaptive qualities of brooding rumination. If this is the case, it might explain why reflective pondering has an adaptive relationship with executive control in the current community population. Consequently, if reflective pondering only has adaptive features in the absence of depression, it would be important for interventions targeting reflective pondering to be aimed at adolescents prior to the onset of depression. Further research is however needed to confirm the adaptive nature of reflective pondering on executive control, in both clinical and non-clinical adolescent populations.

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[Figure 1 has been supplied separately as a tiff document and below is the title of the figure]

Figure 1: An example of a block of trials within each condition during the Internal Switch Task (constructed by author based on an image from De Lissnyder, Koster, Everaert, et al., 2012).

Table 1. *Mean Scores, Standard Deviations, and comparisons between all W1 and W2 Measures.*

		Wave 1		Wave 2		*t*	*d*
		M	SD	M	SD		
Executive control:	Switch cost (Emotion)	541.98	310.17	485.43	293.66	2.22*	0.38
	Switch cost (Non-Emotion)	530.67	298.98	485.17	287.04	1.63	0.27
Rumination:	Brooding rumination	11.36	3.57	10.74	3.67	2.58*	0.43
	Reflective pondering	9.54	3.51	8.99	3.41	2.22*	0.38
Depressive symptoms:	BDI – ii	15.85[1]	11.96[2]	14.84[1]	11.33[2]	1.81[1]	0.30
Anxiety symptoms:	MASC - ii	61.64[1]	24.28[2]	59.69[1]	25.93[2]	1.55[1]	0.26

*$p < .05$.

[1]*Pooled estimates*

[2]Estimates averaged from results of the five imputed data sets

Note. RRS = Ruminative Response Scale, BDI-II = Beck Depression Inventory-II, MASC-II = Multidimensional Anxiety Scale for Children-II.

Table 2. *Bivariate Correlations Within and Across Time Points*[1].

	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
1. W1 Switch Cost (E)[2]	.43***	-.09	-.15*	-.14*	.05	.48***	.45***	-.02	-.14*	-.15*	-.02	-.07	-.03
2. W1 Switch Cost (NE)[3]	-	-.04	.03	-.07	.06	.38***	.33***	.08	-.06	-.09	.06	-.19*	.01
3. W1 Brooding		-	.67***	.71***	.65***	-.05	-.00	.68***	.63***	.61***	.55***	.20*	.24***
4. W1 Reflective			-	.58***	.52***	-.16*	-.09	.50***	.66***	.48***	.52***	.22***	.17*
5. W1 BDI				-	.69***	-.06	.00	.59***	.63***	.83***	.60***	.19*	.38***
6. W1 MASC					-	.11	.12	.54***	.57***	.65***	.82***	.00	.31***
7. W2 Switch Cost (E)[2]						-	.41***	-.06	-.12	-.03	.06	-.07	.16*
8. W2 Switch Cost (NE)[3]							-	.01	.02	.05	.04	.06	.09
9. W2 Brooding								-	.71***	.69***	.62***	.03	.25**
10. W2 Reflective									-	.68***	.64***	.13	.25**
11. W2 BDI										-	.69***	.11	.32***
12. W2 MASC											-	-.05	.33***
13. Age												-	-.01
14. Sex													-

***$p < .001$, **$p < .01$, *$p < .05$.
[1]Pooled correlations
[2]E = Emotion
[3]NE = Non-Emotion
Note. BDI-II = Beck Depression Inventory-II, MASC-II = Multidimensional Anxiety Scale for Children-II.

Table 3. *Hierarchical Regression Analyses of W1 Rumination Scores on W2 Executive Control Scores When Processing Emotional Information.*

		Dependent Variable: W2 Switch cost (Emotion)	
Step	Predictors	Step 1 β^1	Step 2 β^1
1.	Sex	.19*	.18*
	Age	.03	.06
	W1 Depressive symptoms	-.17	-.10
	W1 Anxiety symptoms	.13	.19
	W1 Switch cost (Emotion)	.37***	.33***
	W1 Switch cost (Non-Emotion)	.20*	.23**
	W1 Brooding rumination	-.07	.03
2.	W1 Reflective pondering		-.22*

***$p < .001$, **$p < .01$, *$p < .05$. *[1]Pooled estimates*

Table 4. *Hierarchical Regression Analyses of W1 Rumination Scores on W2 Executive Control Scores When Processing Non-Emotional Information*

		Dependent Variable: W2 Switch cost (Non-Emotion)	
Step	Predictors	Step 1 β^1	Step 2 β^1
1.	Sex	.09	.08
	Age	.13	.16
	W1 Depressive symptoms	-.03	.04
	W1 Anxiety symptoms	.09	.15
	W1 Switch cost (Emotion)	.37***	.34***
	W1 Switch cost (Non-Emotion)	.18*	.21*
	W1 Brooding rumination	.11	-.02
2.	W1 Reflective pondering		-.19

***$p < .001$, **$p < .01$, *$p < .05$. *[1]Pooled estimates*